National Park Service
U.S. Department of the Interior

Glacier National Park

# Earth Science

## *5th-9th Grade Field Trip*

## Preparing For Your Trip

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## *Earth Science 5th-9th Grade Field Trip*

## Welcome and Need to Know Information

Dear Teacher,

This packet contains all the information you will need to prepare your students for an Earth Science field trip to Glacier National Park.

- The field trip lesson plan on pages 14-19 should answer most questions about field trip logistics, objectives, and schedules.
- The rest of the lessons are meant to prepare students for the concepts and vocabulary highlighed on the field trip. Each activity can serve as a pre-visit introduction or a post-visit assessment/extension. A suggested unit plan organization is located on the following page.
- Glacier's SmartBoard lessons are a great way to supplement this unit.
- Visit our **website** for more lesson plan ideas and background information for any field trip. This guide contains only a sample of what is available.

Be sure to confirm the date(s) and meeting place for your field trip (received via email are correct). There is no cost for this field trip. A waiver for the park entrance fee has been processed for your class(es). Travel grants from the Glacier National Park Conservancy may be available to schools with restricted travel budgets.

The education ranger assigned to your group will call you before your field trip date to discuss the schedule and answer any questions. You can also reach them at 406-888-7899.

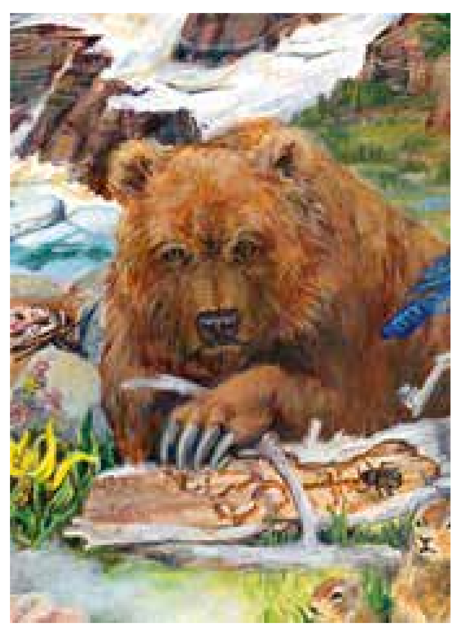
Our education programs are made possible by the support of the Glacier National Park Conservancy. Thank you for introducing your students to the National Park Service mission and the wonders of Glacier!

Glacier National Park
Education Staff

Glacier National Park
CONSERVANCY

## Glacier's Education Goals

- Provide opportunities for the students to form emotional and intellectual connections with park resources and values.
- Introduce students to the National Park Service mission and significances of Glacier.
- Provide curriculum-based, outdoor education experiences that are age appropriate and supplement classroom learning objectives.
- Introduce students to the value of protecting natural and cultural resources for current and future generations and to encourage actions we can all take to be good stewards of this special place.



# Suggested 5-Day Lesson Sequence with Field Trip

| | Summary | Objectives<br>*Students will know:* | MT and Next Generation Science Standards | Materials |
|---|---|---|---|---|
| **Pre-Field Trip**<br>*Lesson 1-Locating Glacier National Park* | Students label maps to locate and identify landmarks near Glacier National Park in different geographic areas. | • Glacier's location relative to Montana; the Continental Divide; Waterton Lakes; Alberta and British Columbia; and the students' community.<br>• Glacier's location in relation to the Pacific Northwest and North America.<br>• That Glacier's water ultimately flows into major watersheds. | MT.SS.K-12.3.2 Students apply geographic knowledge and skills (e.g., location, place, human/environment interactions, movement, and regions).<br>5-ESS1-2. Represent data in graphical displays to reveal patterns of daily changes in length/direction of shadows, day/night, and the seasonal appearance of some stars in the night sky. | • Map handouts (Glacier NP, Pacific Northwest and Western Canada, North America)<br>• List of landmarks<br>• Colored pencils |
| **Pre-Field Trip**<br>*Lesson 2-Carving Mountains* | Through individual and group research, students will define specialized glacial terms and learn to recognize the landforms they represent. Students will illustrate the landforms using clay modeling. | • How to identify variety of glaciated features.<br>• Describe how glaciers change the landscape. | MT.SCI.K-12.4.1 ...demonstrate knowledge of the composition, structures, processes and interactions of Earth's systems and other objects in space.<br>MS-ESS2-2. Construct an explanation based on evidence for how geoscience processes have changed Earth's surface at varying time and spatial scales | • Pictures of geological features of Glacier<br>• Paper<br>• Recycled 4' by 4' plywood boards<br>• modeling clay and tools<br>• ruler, pins, scissors, pens<br>• Plastic covering |
| **Pre-Field Trip**<br>*Lesson 3-Model Glaciers* | Students use ice, sand, and gravel to demonstrate how glaciers move and explain the features they leave behind on the landscape. | • How glaciers move.<br>• How glaciers change the landscape. | MT.SCI.K-12.1.2 ... demonstrate the ability to design, conduct, evaluate, and communicate results and reasonable conclusions of scientific investigations.<br>MS-ESS2-2. Construct an explanation based on evidence for how geoscience processes have changed Earth's surface at varying time and spatial scales | • Small sandbox<br>• Sand<br>• Gravel/small rocks<br>• Elongated containers (varying sizes)<br>• Access to a freezer |
| **Field Trip Day!**<br>*Earth Science* | Rangers lead students on a 4+ mile hike and explore a variety of geologic processes. | Vary depending on field trip. Talk to the ranger before your visit for more information. | Vary depending on field trip. Talk to the ranger before your visit for more information. | • Warm clothes<br>• Nametag<br>• Lunch<br>• Adult helpers |
| **Post-Field Trip**<br>*Lesson 4-Create a National Park* | Students create a mini-national park in a specified outdoor area, marking a nature trail and providing visitors with information about the park. | • Why do we need national parks?<br>• The characteristics of a national park<br>• At least three problems facing national parks<br>• How to write a persuasive proposal for a national park designation. | MT.SCI.K-12.3.4 Demonstrate knowledge of characteristics, structures, functions of living things, processes and diversity of life, and how organisms interact with each other and the environment.<br>3-LS4-3 Construct an argument with evidence that in a habitat some organisms can survive well, some survive less well, and some cannot survive at all. | *For each pair of students:*<br>• Clipboard<br>• Paper, pencil<br>• Hand lens<br>• String (15 ft. long)<br>• Six popsicle sticks<br>• Poker chips (at least one per student) |

# Lesson 1: Pre-Visit

## *Locating Glacier National Park*

**Materials:**
- *Map handouts (Glacier National Park, Pacific Northwest and Western Canada, North America)*
- *List of landmarks*
- *Colored pencils*

**Vocabulary**

Continental Divide, national forest, national park, Indian Reservation, Peace Park, triple divide, watershed.

**Method**

Students will label three maps to locate and identify landmarks near Glacier National Park in ever greater geographic areas: Glacier National Park and surroundings; the Pacific Northwest and Western Canada; and North America.

**Objectives**

Students will be able to:
- Locate Glacier National Park and other landmarks within Montana in relation to: the Continental Divide; Waterton Lakes National Park; Alberta and British Columbia; the three divides :Pacific, Hudson Bay and Gulf of Mexico; and the students' community.
- Locate Glacier and Montana in relation to the Pacific Northwest and in relation to North America.
- Identify the bodies of water that Glacier's waters ultimately flow into.

**MT State Social Studies Standard**

MT.SS.K-12.3.2 Students apply geographic knowledge and skills (e.g., location, place, human/environment interactions, movement, and regions).
- Students will locate on a map or globe physical features (e.g., continents, oceans, mountain ranges, and forms) natural features (e.g., flora fauna) and human features (e.g., cities, states, national borders) and explain their relationships within the ecosystem.

**Next Generation Science Standard**

Disciplinary Core Idea: ESS2.C: The Roles of Water in Earth's Surface Processes
- Water's movements - both on the land and underground cause weathering and erosion, which change the land's surface features and create underground formations. (MS-ESS2-2)

**Background**

Even before Glacier National Park was established in 1910, it was an important cultural and economic contributor to the state of Montana. The scenery of the area attracted visitors, mostly by train, well before the park was established. The Great Northern Railroad (now Burlington Northern Santa Fe) still runs along the park's southern border and Amtrak still carries visitors to and from the area.

## Background

For Native Americans whose homelands encompassed Glacier, the area has great spiritual significance. The Blackfeet refer to the mountains here as the "backbone of the world." The Kootenai translation for the Lake McDonald area refers to it as "a good place to dance." Today, the Blackfeet Reservation shares Glacier's eastern border. The Kootenai, Salish, and Pend d'Oreille are part of the Flathead Reservation south of Glacier

Glacier National Park straddles the Continental Divide. The divide defines watersheds. West of the divide water flows to the Pacific Ocean and east of the divide water flows to the Gulf of Mexico or Hudson Bay. Because water from the park flows in three different directions, Glacier contains a rare geologic feature-a triple divide. Water from Glacier passes through many different places on its way east or west. The people and animals living around Glacier depend on this water. For instance, Lake McDonald eventually flows into Flathead Lake via the Flathead River. Along the way that water passes through Columbia Falls and Kalispell.

The Flathead National Forest shares Glacier's western and southern boundaries. The Blackfeet Indian Reservation shares the eastern boundary. North of the park are the Canadian provinces of Alberta and British Columbia in Canada. Waterton Lakes National Park is Glacier's sister park in Alberta, Canada. The two parks merged in 1932 to become the world's first International Peace Park.

## Procedure

1. Using a globe or North American map, introduce students to the location of Montana in the United States and in North America. Point out the location of various landmarks - Rocky Mountains, Canadian Border, the Pacific Ocean, Gulf of Mexico, and Hudson Bay, the plains of eastern Montana.
2. Then, using the transparencies, for the United States and North America see if together as a class, you can locate and label those same landmarks.
3. Discuss the location of the students' hometown on the map of Glacier and vicinity. Also discuss the location of various protected lands within Montana - national forests, national parks. Point out the Indian Reservations, the three watersheds, and major rivers.
4. Distribute a copy of the three maps to each student. Decide in advance which things on each map you want them to be able to label. On the North American map they can label the oceans, countries, and state of Montana. On the Pacific Northwest map, they could label the Canadian provinces, American states, and the ocean. On the Glacier map, they could label their home town, the rivers, the lakes, and the 3 watersheds.

## Evaluation

On a road map have students trace the route from their school to Glacier National Park. Have them do the same for other landmarks on the map as well.

## Extension

Discuss the importance of the geographic location of Glacier National Park. Have students hypothesize as to why certain types of plants and plant communities live in the park. What about the different animal species that live in Glacier?

Name:________________________________________ Date:__________________

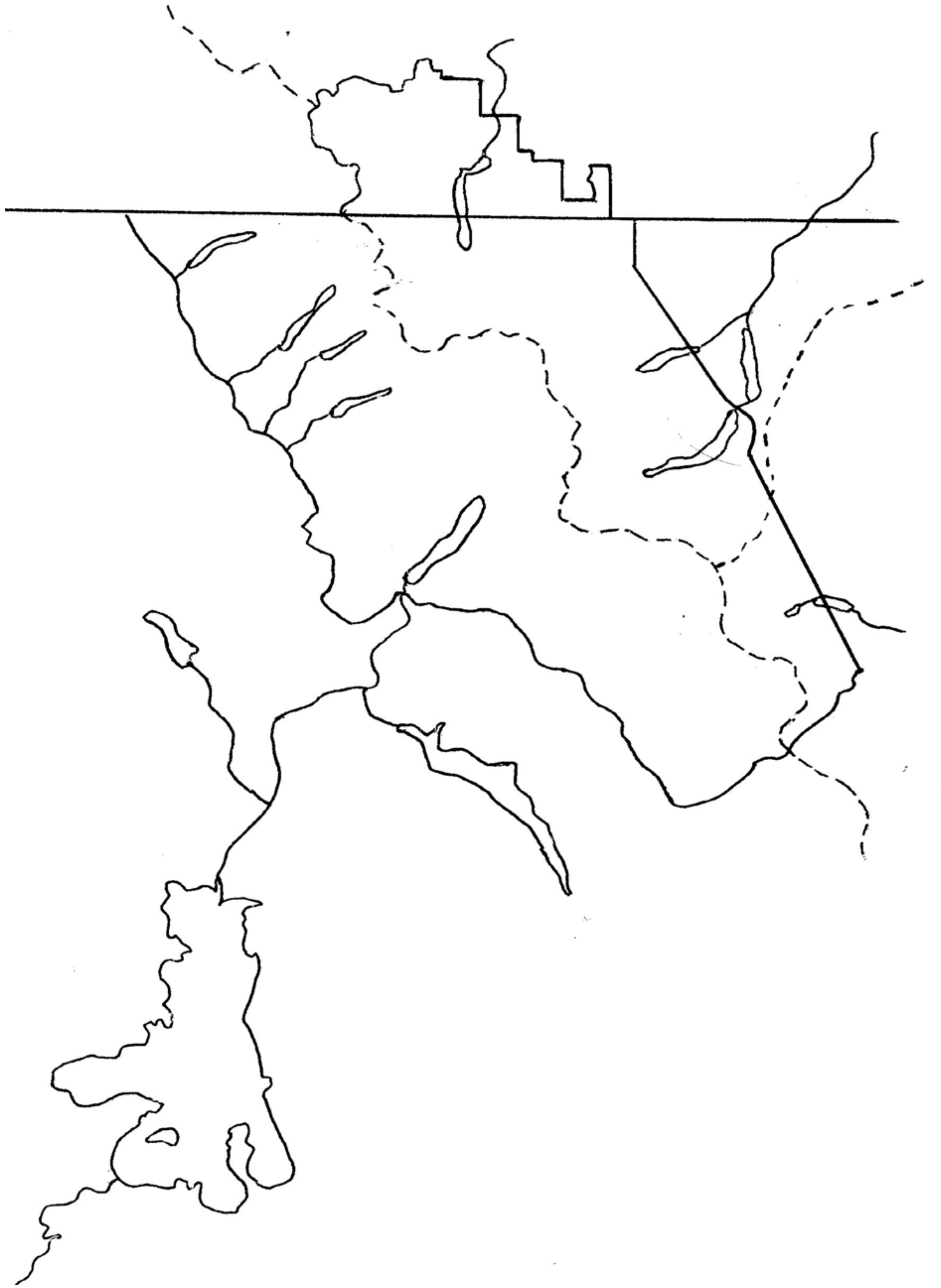
# Locating Glacier National Park in North America

Name:_______________________________________________ Date:__________________

# Locating Glacier National Park in the Pacific Northwest

Name:______________________________________________ Date:__________________

# Locating Glacier National Park in Northwest Montana



# Lesson 2: Pre-Visit

## *Carving Mountains* INSTRUCTIONAL CARVING MOUNTAINS VIDEO

*This activity is from Work House: A Science and Indian Education Program with Glacier National Park.

**Materials:**

* *Research materials to include Earth Science texts, books dealing with the geology of Glacier National Park and Montana*
* *Images of geological features of Glacier National Park, acquired online*
* *One or more raised relief maps of Glacier National Park*
* *Paper for recording research & for labels*

* *Several recycled 4' by 4' plywood boards*
* *Moist, recycled pottery clay or large supply of modeling clay*
* *Tools for working clay*
* *An appropriate ruler to establish a reference scale for elevations*
* *Pins to hold labels*
* *Scissors*
* *Fine-point pens*
* *Plastic covering to prevent drying out of models in general*
* *Good dictionary*

### Vocabulary

Alpine meadow, avalanche, col, crevasse, esker, fold, glacial trough, glaciation, hanging valley, kettle lake, lateral moraine, medial moraine, moraine, mountain pass, mountain range, outwash plain, peak, plateau, terminal moraine, tree line, valley glacier.

### Method

Through individual and group research, students create a clay model of a mountain range with glacial features labelled.

### Objectives

Students will be able to:
- Compile team dictionaries of mountain and glacial terms.
- Work cooperatively to design and build a mountain range out of clay that contains glacial features.
- Optional: build models to scale.
- Identify landforms in their clay models that have cultural significance.

### MT State Science Standard

MT.SCI.K-12.4.1 Students, through the inquiry process, demonstrate knowledge of the composition, structures, processes and interactions of Earth's systems and other objects in space.

A proficient student will be able to model and explain the internal structure of the Earth and describe the formation and composition of Earth's external features in terms of the rock cycle and plate tectonics and constructive and destructive forces.

### Next Generation Science Standard

MS-ESS2-2. Construct an explanation based on evidence for how geoscience processes have changed Earth's surface at varying time and spatial scales

**Background**

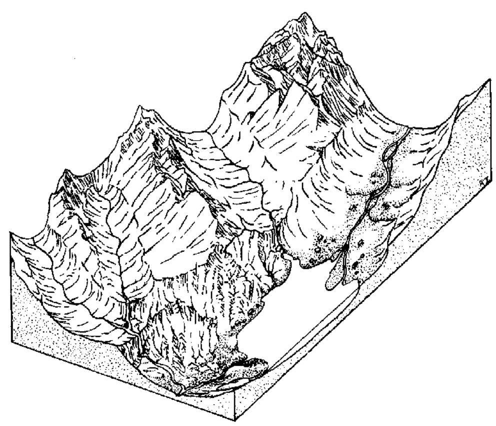
Make glacial feature labels and or definition cards for each group. Have boards/trays for models to be built on, clay ready and place to put models out. This activity is designed to get students research experience on glaciers and the tactile experience of building a scale model of mountains with glacially carved features.

**Procedure**

1. Use the vocabulary list provided (and add others of your choosing) as a guide for students to use in compiling team dictionaries of mountain and glacial terms.

2. Divide the students into cooperative learning groups; give each group fresh balls of clay and tell them to sculpt mountain formations on a team board until they are satisfied with what they have done. It will add relevance if students are encouraged to replicate an area of the park with which they are familiar. The raised relief maps of the park are a great resource for this. A math component can be added if students must do it to scale! (1 inch = 1000 feet elevation for example, so a 10,000 foot peak would be 10 inches high).

3. Provide glacial feature labels (or definition cards) to an appointed or chosen chairperson for each team. Ask individuals to identify or remold specific features into the group of mountains. This requires alterations of the original mountains. When there is some question about a formation to be labeled, students may use available books and other resources for immediate research.



Glacial Features- can you find a hanging valley? Glacial trough? (Glacier NP Digital Image Library)

**Evaluation**

When the labeling and remolding are complete, the students should be able to define and discuss their work.

**Extension**

Using the vocabulary and other terms they came across in their research, each team should generate a dictionary definition of mountain and glacial terms. When dictionaries are completed, students should examine other teams' models and help each other refine formations and definitions. This process will help them to internalize their research.

The next obvious question might be, "What do we do with the clay models when the students finish?" Ask the students! Maybe they would like to paint them, show them to another class or parents, write an adventure story that takes place in the mountains, generate some appropriate weather in their models, pour water over them to trace natural drainage, or make models of indigenous animals and plants to put in their created environments.

# Lesson 3: Pre-Visit

## *Model Glaciers*

INSTRUCTIONAL MODEL GLACIERS VIDEO

*This activity is from Work House: A Science and Indian Education Program with Glacier National Park.

**Materials:**

* *Small sandbox*
* *Sand*
* *Gravel/small rocks*
* *Elongated containers (varying sizes)*
* *Access to a freezer*

### Vocabulary

Arete, cirque, hanging valley, horn, moraine, glacier, glacial flour, till, tributary, U-shaped valley, V-shaped valley.

### Method

Using a dish pan or sand box, students place/move frozen ice blocks with gravel/rocks in them through the sand to form glacially carved valleys, cirques, tarn lakes, etc.

### Objective

Students will be able to:

- Form glacial features in a sand box model river valley.
- Identify glacial features on the landscape - terminal and lateral moraines, the headwall, cirques, tributary glaciers, and hanging valleys.

### MT State Science Standard

MT.SCI.K-12.1.2 Students, through the inquiry process, demonstrate the ability to design, conduct, evaluate, and communicate results and reasonable conclusions of scientific investigations.

- A proficient student will select and use appropriate tools including technology to make measurements and represent results of basic scientific investigations.

### Next Generation Science Standard

MS-ESS2-2. Construct an explanation based on evidence for how geoscience processes have changed Earth's surface at varying time and spatial scales.

### Background

Two of the most accessible valleys in the park - Lake McDonald and St. Mary- are both excellent sites to observe many glacially carved features and contain the two largest glacially formed lakes in the park. Apgar is located at the base of Lake McDonald and the village of St. Mary is at the base of St. Mary Lake. The glacial troughs in which they lie afford an uninterrupted

**Background Continued**

view of the work of ice. For a trip to Avalanche, students will drive through the Lake McDonald Valley and see the role glaciers have played in shaping the Valley. Weather permitting, they will be able to see: lateral and end moraines, a U-shaped valley, and the Garden Wall, an arete. Additionally, a trip through the Apgar area to get to the Avalanche Picnic Area and trailhead parking will bring students to the setting for the Kootenai story, The Place Where They Danced. Kootenai cultural leaders re-affirm in We Ask That You Walk Lightly, the significance of this place to the Kootenai and reminds all visitors to be good stewards and to be respectful when in the park.

**Procedure**

1. Freeze gravel and small rocks into ice blocks in small containers so they will have a rough bottom when they start to melt. Thaw the containers enough the day of class to get the ice out. Use damp sand in a box (dish tub works if inside) to mold into mountains. Have the students form mountains and river valleys in the river sand box.
2. Take out the prepared ice blocks that have stones frozen into them. Use a large ice block to represent a large mountain glacier and several smaller blocks to represent smaller tributary glaciers.
3. Place the large block at the head of the valley the students have created in the sand and slowly bulldoze a path down the river valley. Point out the gouging and plucking along the way. When you reach the terminal point of the valley, point out the terminal moraine. Be sure that you are gouging nearly to the bottom of the sandbox or trough. Point out the lateral moraines along the side of the glacier's path.
4. Give some of the students small glaciers and invite them to work a few tributary glaciers. Ask if they can produce aretes, hanging valleys, cirques, horns, etc. When they have finished have them leave their remnant glaciers against the headwalls.

**Evaluation**

Some time later have the students look at the debris left in the cirque as the ice block melts. Ultimately there will only remain a little pile of "till" and a small "tarn" lake if the clay layer in your trough keeps the water from all draining out.

**Extension**

As a special treat and review, get several half gallon blocks of Neapolitan ice cream, marshmallow cream topping, ground nuts to represent rocks, and whatever else you might find tasty and relevant. Then get down to business with an ice cream scoop. While reviewing glacial terminology and carving formations with the scoop, fill cups for the students who can correctly identify the latest formation.

Take a tour through Glacier's Cultural Resource Guide- there are digital images, more lesson plans, fact sheets about Glacier's cultural resources, and more!

# Field Trip Day!

## *Earth Science in Glacier*

**Vocabulary**

Varies by field trip but may include: Blackfeet, climate change, dichotomous key, erosion, fossil, glacial flour, glaciation, igneous, Kootenai, landform building, lichen, metamorphic, moss, mud crack, national parks, ripple mark, rock cycle, Salish, sedimentary, shrubs, silt, stromatolite, succession, timeline, trees, weathering.

**Method**

The scenery in Glacier National Park provides evidence of a range of geologic processes that have shaped the landscape. Rangers lead students on a 4+ mile hike and explore sedimentation, mountain building, glaciation, rocks and minerals, erosion, weathering, and soil formation. The length of these hikes and level of information is geared toward secondary age students and is a challenge to fit into a regular school day schedule. The ability to have an extended field day is recommended for this program.

**Objectives**

Students will be able to (depending on grade level and weather condition):

- Describe the National Park Service misison and explain why Glacier was established.
- Use a dichotomous key to identify trees and describe something unique about the species found here.
- Draw a series of pictures to show how plant succession can change a bare rock into a mini-forest over time (include lichen, moss, shrubs and trees).
- Name the three main groups that rocks are classified into- sedimentary, metamorphic, and igneous-plus explain how each type is formed.
- Tell how stromatolites, mud cracks and ripple marks are evidence of the rocks here having formed under water.
- Tell how the rock cycle works (i.e. explain why it is a “cycle”.)
- Give an example of how water can affect landform building and destruction.
- Find examples of glaciation on landscape (hanging valleys, striations, etc).
- Identify examples of erosion and weathering and explain the difference.

**Objectives, Continued**

- Explain how the rhyme (silt, tilt, slide and glide!) describes the main geologic events that shaped the landscape we see in Glacier National Park today.
- Discuss how Kootenai, Blackfeet, and Salish/Pend d'Oreille stories describe events (volcanic eruptions, glaciers, etc) that change the landscape in and around Glacier.
- Describe how glaciers can be evidence of climate change and how this area is likely to change.

**Background**

One of the reasons Glacier National Park was established was to preserve the unique geology of this region and the evidence of earth's changing features. See the Appendix for additional information about geology.

**MT State Science Standards**

MT.SCI.K-12.4 Students, through the inquiry process, demonstrate knowledge of the composition, structures, processes and interactions of Earth's systems and other objects in space.

- A proficient student will be able to model and explain the internal structure of the Earth and describe the formation and composition of Earth's external features in terms of the rock cycle and plate tectonics and constructive and destructive forces.
- A proficient student will be able to differentiate between rock types and mineral types and classify both by how they are formed and the utilization by humans
- A proficent student will be able to use fossils to describe the geological timeline

**Next Generation Science Standards**

MS-ESS2-2 Construct an explanation based on evidence for how geoscience processes have changed Earth's surface at varying time and spatial scales.

**Sample Field Trip Schedule**

Flexibility for weather conditions, bus problems, etc. is essential to having an enjoyable visit. No two school programs are exactly alike, but the following schedule represents a typical trip.

8:30 a.m. – 9:30 a.m. Travel to the Park.

Simple assignments can be completed during this time. Point out sights along the way that relate to the park story such as mountain uplifting, glacially carved valleys or mountain passes, river crossings, and canyon formations. You may also want to review vocabulary words or ecological concepts.

9:30 a.m. – 9:45 a.m . Meet Park Rangers at Avalanche Parking/Picnic Area

After a brief welcome by the park rangers to Glacier National Park, the ranger(s) will talk with the chaperones and teacher(s) about the schedule for the day, and then the students will take a bathroom break.

9:45 a.m. – 12:00 p.m. Hike to Avalanche Lake, about 2 miles.

12:00 p.m. – 12:30 p.m. Lunch at the Lake.

12:30 p.m. – 2:00 p.m. Return Hike.

2:00 p.m. – 2:15 p.m. Bathroom Break and Concluding Activities.

Rangers review the educational objectives for the day and engage all the students in a fun activity to assess their learning.

2:15 p.m. – Bus Leaves the Park.

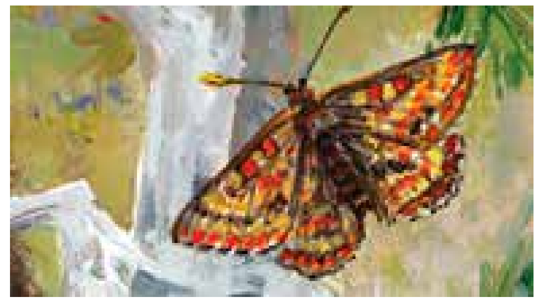
**Protecting the National Park**

In order to have a fun and exciting experience, a firm framework of rules should be discussed in advance. The discussion should include the following points:

- Respect both plants and animals in Glacier National Park.
- Harassing animals and picking flowers, pine cones, feathers, and other natural objects in the park are illegal.
- Respecting rights of others in Glacier by refraining from disruptive behavior.
- Respecting each other, the ranger, chaperones, and teachers (walk on trails, keep hands to yourself, wait to talk until the instructor is finished, etc.)

**School Regulations and Safety**

Teachers are responsible for following school regulations regarding parental permission slips, travel authorization/insurance, etc. An accident can ruin a field trip and jeopardize future ones. Safety is of utmost importance. Students must be with adults at all times.



**Clothing**

Remind students to check the weather and bring appropriate, comfortable clothing, including a hat, rain pants, warm waterproof coat, gloves/mittens, and hiking boots. Encourage students to bring extra layers.

**Name Tags**

For safety and courtesy, rangers prefer to call students by name. Masking tape with names written in big letters, works well. If you make name tags as a pre-visit activity, be sure they are easy to read and stay on when the students are active.

**Food and Lunches**

Everyone needs a lunch and drink. Resealable drinks work best as they can be refilled and saved. No food or drink is available at the park. Students are expected to clean up the lunch area. Food/gum are prohibited except at designated times.

**Groups**

See the chaperone guidelines on the next page. Typically it works best to assign adults to groups of students before arriving at the park. (A typical bus of 45 -5th grade students would be divided into nine groups of five students each.)

**Items to Leave Behind**

Students should not bring iPods, CD players, radios, cell phones, or money. These items can be lost and may be a distraction. Adults should also leave cell phones at home (or turned off) during the field trip. Cameras and binoculars will not be needed and may only be brought if they will be used at ranger approved times. Designating one adult as the class photographer and asking them to take pictures throughout the day to share with everyone is a great alternative.

**Safety**

An accident can ruin a field trip and jeopardize future ones. Safety is of the utmost importance. Students should stay with adults at all times.

## Chaperone Guidelines and Responsibilities

The chaperone requirements for ranger-led educational field trips to Glacier are (these numbers include the teacher):

- Kindergarten - 2nd Grade = 1 adult for every 3 students (example: 22 students, 8 adults required/allowed).
- 3rd - 5th grade = 1 adult for every 5 students (example: 22 students, 5 adults required/allowed)).
- 6th grade and higher = 1 adult for every 10 students (example: 22 students, 3 adults required/allowed).

Please assist your child's teacher by volunteering to help with a field trip to Glacier, or **by respecting when your help is not needed because it exceeds the park's guidelines listed above.** Our facilities, staffing, and resource protection mandate that we limit not only the number of students we can handle per trip, but also the number of adults with each group.

If you are selected to help with a field trip, realize that you are an important partner in our program. We need your participation and cooperation to make the trip a success and will be asking this of you:

- **Do not bring siblings who are not part of the class.** Your full attention is needed to help monitor the students assigned to you that day.
- **Please ride on the school bus.** It makes getting everyone through the entrance station much easier and avoids parking problems.
- **Assist with safety.** It will be one of your primary duties as a chaperone.
- **Be an active participant.** Students will want to participate if you do.
- Provide guidance to students for lunch and clean-up.
- Help set boundaries and provide leadership.
- Guide the learning process and help focus students on the activity or speaker.
- **Please consult with your school administrators about the policy regarding firearms on school sponsored events.** We have never had an injury from a wildlife encounter in over 20 years of conducting school field trips in Glacier. Rangers carry bear spray, first aid kits, and radios and will show the group how to hike and recreate safely while in the park.
- Most importantly go with the flow, adapt, and have fun in Glacier! The students pick up on how you react if you are having fun, they will too!

## Sample Teacher Evaluation of Ranger and How Day Went

United States Department of the Interior

NATIONAL PARK SERVICE
Glacier National Park
West Glacier, Montana 59936

IN REPLY REFER TO:

Thank you for bringing your students to Glacier National Park. Your candid and thoughtful responses to the questions below will be used to help us further improve our programs.

1. Please rate how enthusiastically the ranger engaged your students
   - Exceeded my expectations
   - Met my expectations
   - Did not meet my expectations

2. Please rate how respectfully the ranger engaged with you and your chaperones
   - Exceeded my expectations
   - Met my expectations
   - Did not meet my expectations

3. Please rate how appropriate the ranger's teaching techniques were for your students' grade level
   - Exceeded my expectations
   - Met my expectations
   - Did not meet my expectations

4. Please rate how well prepared the ranger was to teach and lead your class
   - Exceeded my expectations
   - Met my expectations
   - Did not meet my expectations

5. How well did the ranger attend to the safety of all participants?
   - Very well
   - Somewhat well
   - Not at all well
6. Please let us know what the ranger did well and what he/she can improve upon

7. Please rate how well the program activities met the curriculum learning objectives
   - Very well
   - Somewhat well
   - Not at all well
8. Please rate how appropriate the vocabulary and concepts were for your students' age level.
   - Very appropriate
   - Somewhat appropriate
   - Not appropriate
9. Please rate how much your students' understanding of concepts you are teaching in the classroom increased.
   - Exceeded my expectations
   - Met my expectations
   - Did not meet my expectations
10. Please let us know what content and activities worked well and what we can improve upo

11. How would you rate the ease of registering for the GNP program?
    - Very easy
    - Somewhat easy
    - Not easy

12. Please rate the usefulness of the pre-arrival resources you used by placing an "x" in the appropriate box.

| | Essential | Useful, not essential | Not useful | Don't know/Didn't use |
|---|---|---|---|---|
| Pre-visit lessons | | | | |
| Tips for a successful field trip | | | | |
| Chaperone guidelines and responsibilities | | | | |
| Meeting map | | | | |
| Field trip logistics and timeline | | | | |
| Learning objectives and alignment with state standards | | | | |
| Pre-trip phone call with GNP ranger | | | | |
| Post-visit lessons | | | | |

13. If you used pre- and/or post-visit lessons, please describe the ones which you found most useful.

## Sample Ranger Evaluation of Class and How Day Went

United States Department of the Interior

NATIONAL PARK SERVICE
Glacier National Park
West Glacier, Montana 59936

IN REPLY REFER TO:

Dear________________________________:

Thank you for participating in the education program at Glacier National Park on _________________________.

We hope that the field trip provided your class with an opportunity to better understand the significance of their national park. As a follow-up we are sending all participating teachers this evaluation to help you better prepare for your next trip. This evaluation is intended to point out strengths as well as areas that need additional attention.

| | |
|---|---|
| Students wore name tags and were properly dressed for the day. | |
| Snacks/lunches were organized for easy distribution and everyone assisted with lunch clean-up. | |
| There were an appropriate number of chaperones present. | |
| Chaperone(s) actively participated in supervising students. | |
| Pre-site class preparation was evident. | |
| Class behavior facilitated a positive learning environment. | |

Additional comments:

Sincerely,

Park Ranger(s)

# Lesson 4: Post-Visit

## *Create a National Park*

**Materials:**

*For each pair of students:*
- *Clipboard*
- *Paper, pencil*
- *Hand lens*
- *String (15 ft. long)*
- *Six popsicle sticks*
- *Poker chips (at least one per student)*

### Vocabulary

Cultural resources, national park, natural resources, .

### Method

Students create a mini-national park in a specified outdoor area, marking a nature trail and providing visitors with information about the park.

### Objectives

Students will be able to:
- Answer the question: Why do we need national parks?
- Describe characteristics of a national park
- List three problems facing national parks
- Analyze the information learned and write a persuasive proposal for a national park designation.

### MT State Science Standard

MT.SCI.K-12.3.4 Students, through the inquiry process, demonstrate knowledge of characteristics, structures, functions of living things, processes and diversity of life, and how organisms interact with each other and the environment.
- A proficient student will explain cause and effect relationships between nonliving and living components within ecosystems; and explain individual response to the changes in the environment.

### Next Generation Science Standard

3-LS4-3 Construct an argument with evidence that in a habitat some organisms can survive well, some survive less well, and some cannot survive at all.

### Background

There are over 400 national park areas in the National Park System. They have been set aside by Congress to preserve and protect the best of our natural, recreational, and cultural resources for the use and enjoyment of all persons, including future generations. For this lesson, we will be discussing parks set aside for their natural wonders. These parks are as diverse as the visitors who come to them. A park may offer any one or a combination of the following: camping, wilderness, hiking trails, scenic overlooks, nature trails, campfire programs, boat tours, canoeing, fishing, boardwalks, rock climbing, swimming, or tours of historic buildings and cultural sites.

A park may have several outstanding natural features for which it was set aside, or it may be preserved for a specific site. Park management is set up

## Background, Continued

much like a school system, the rangers being the teachers. Each day brings new challenges to a park and its resources. Some parks may have numerous problems facing them.

Upon arriving at many of the national parks, the visitor pays a small entrance fee and is handed park information outlining major resources and sites to visit. Larger parks have a visitor center where rangers disperse information about the park. One part of a park ranger's job is to interpret the park resources and problems to the visitors so that they can understand the concerns of the park. Why? Because parks belong to the people and they must learn about these valuable resources and how to protect them!

## Procedure

1. Discuss the concept of a national park with your students. Ask students if they have ever been to a national park. What makes it different from a state park or a county park?
2. Ask students what they would like in a national park, if they were to create a "perfect park." Why set up a national park? Who owns national parks?
3. Pair off the students. Distribute the materials listed on the preceding page to each pair.
4. Assign, or let each pair choose, an outdoor spot for their national park. Using their string, they should rope off the area.
5. Students must move about their national park on hands and knees. Using the hand lenses, the students should choose the scenic values of their park; a hole might be a canyon, a rock might be a mountain, for instance. The popsicle sticks can be used to mark the trails or scenic spots.
6. Give the class 20-25 minutes to set up the trails in their park. After the students have marked their parks, they must make a brochure (including a map) to publicize their park.
7. Once the parks are ready for business, the "rangers" (the paired students) must advertise their park. They should advertise their park by shouting out its attributes. Ask the pairs to split up.
8. One student in the pair should remain in the park to interpret it, while the second visits other national park. The students may then switch. The poker chips are the entrance fee needed to visit another national park. Every student must visit at least one national park.
9. After they have visited the national parks, ask students the following questions: Did they have problems getting visitors to come to their park? Were visitors always careful with the parks' resources?
10. Did they have too many visitors? What would they change? What problems occurred?
11. How would they raise money to improve the park's facilities?

## Evaluation

Discuss why we should have national parks. What can you do to help protect the resources in a national park? Who has the responsibility of preserving and protecting the park for future generations?

## Extension

Write a proposal to get funding to buy a national park. Presentations should be made to the "President" (teacher). Show students how they can participate in the online "Web Ranger" program at www.nps.gov or in a national park "Jr. Ranger" program the next time their families visit a national park.

# Appendix

## *Additional Teacher Background Information*

GEOLOGY

**The Setting**

Over 1800 square miles (4660 sq. km) of the rugged Rocky Mountains are found within the boundaries of Waterton-Glacier International Peace Park. Two mountain ranges, the Livingston and the more easterly Lewis Range trend from northwest to southeast through Glacier. The Continental Divide follows the crest of the Lewis Range. Elevation varies from a low of 3150 feet (960 m) at the junction of the Middle and North Forks of the Flathead River (near the Lake McDonald valley to a high of 10,466 feet (3192 m) on Mt. Cleveland. There are 6 peaks over 10,000 feet (3050 m) and 32 peaks over 9100 feet (2770 m) found in Glacier National Park. The impressive mountains and valleys within the park are the result of approximately 1.6 billion years of earth history and a number of geologic processes, including, erosion, sediment deposition, uplift and thrust faulting and glaciation Waterton-Glacier is a geologic park. The geologic processes happened in three stages:

1. The sedimentation or deposition of the rock;
2. The uplift of the mountains; and
3. The glaciation or carving out of mountain valleys.

Waterton-Glacier has some of the oldest and best preserved sedimentary rocks found anywhere in North America. Usually, over time and with heat and pressure, sedimentary rock becomes metamorphic rock. For example, limestone becomes marble. It is quite unusual that this old rock still retains its sedimentary characteristics.

**Ancient Sediments – 1.6 billion to 800 million years ago**

The majority of the rocks forming the mountains of the Peace Park are the result of the deposition of sediments into an ancient inland sea that existed over 1600 million years ago during the middle Proterozoic Era. The ancient Belt Sea covered parts of present-day eastern Washington, northern Idaho, western Montana, and nearby areas in Canada. During the period of active deposition over 18,000 feet (5500 m) of sediment eroded from nearby highlands and were carried into the sea. Accumulation of sediment subsequently resulted in down-warping of the sea floor. Also, over time and as environmental conditions varied, a variety of different materials were eroded and washed into the Belt Sea. The result was alternating layers of sediments of differing composition. With time, and as the sediments accumulated, the heat and pressure created layers of quartzite, siltite, argillite, limestone, and dolomite. The sedimentary character of the rocks in Waterton-Glacier is clearly evident in the form of preserved mud-cracks, ripples, and layers; the crystal structure of each formation has been slightly metamorphosed, creating what can accurately be called metasedimentary rock. The combined rock formations that occur in Waterton-Glacier are part of the Precambrian Belt Supergroup and are readily visible in the 33 percent of the park above treeline. Because of the age of these rock structures, no developed life forms are found as fossilized remains; instead only fossilized algae beds have been found.

**Stromatolites – a fossil algae colony dating from the Belt Sea**
Six species of blue-green algae that thrived in shallow parts of the Belt Sea played a significant role in the formation of the carbonate rocks of the park. They are mostly found in the Altyn and Helena (Siyeh) Formations. Stromatolites have shapes and internal structures very similar to blue-green algae that live in present-day seas less than 100 feet (30 m) deep. Sunlight allows algae to consume carbon dioxide from seawater and release oxygen in the process. There are two important results from this process:

1. When algae remove carbon dioxide from the seawater, fine particles of calcium carbonate are formed from a chemical reaction. The sticky ooze secreted by the algae also traps fine sediment precipitated from the seawater. Removal of carbon dioxide from seawater caused the formation of large quantities of calcium carbonate, which contributed to the great thickness of carbonate rocks in the park.
2. Oxygen is released into the atmosphere. This was a major factor in producing the oxygen-rich atmosphere that allowed development of oxygen-consuming life forms on earth.

**An Intrusion of Magma - 750 million years ago**
While most of the rock in the Peace Park is metasedimentary in nature, late in the Proterozoic some igneous rock in the form of lava flowed onto the sea floor. Additional igneous material was intruded between layers of limestone forming sills at an even later time. Today the igneous materials are evident as pillow lava formations (black basalt) in the Granite Park area (granite does not occur in the park) and as the Purcell Sill that runs through the Siyeh Limestone, a dark band of igneous rock (diorite) about 100 feet (30 m) thick. The heat of the intrusion forced out the dark organic matter from the surrounding limestone, recrystallizing it into white marble (metamorphic rock). The Purcell Sill is seen throughout the parks, for example on Mt. Siyeh and the north side of Mt. Cleveland in Glacier, and Mt. Blakiston near Red Rock Canyon in Waterton.

**Lewis Thrust Fault – 60-70 million years ago**
Approximately 150 million years ago, collision of crustal plates on what was then the western edge of North America resulted in the beginning of mountain building processes inland that would continue until about 60 million years ago. In the area that would become Waterton-Glacier International Peace Park, massive forces uplifted a slab of rock several miles thick, which slid east some 50 miles (80 km) over much younger rock. The Lewis Overthrust Fault is major evidence of the tectonic events that created the mountain scenes of present day Glacier and Waterton. However, numerous other events were occurring simultaneously; synclinal folding and other types of faulting are also evident in Waterton-Glacier. As a result of the uplift, erosive forces accelerated and over several million years removed the upper layers of material, exposing the rock formations evident in the park today.

**Glaciation: The Ice Age – 2 million years ago**
The geologic event that would define the landscape began with a global cooling trend approximately 2 million years ago. The Pleistocene Ice Age saw large ice sheets repeatedly advance and retreat throughout the temperate regions of North America until about 10,000 years ago. In the area that would become Waterton-Glacier International Peace Park, ice advanced and retreated until probably melting completely about 12,000 years ago. During the ice advances, the lower valleys were filled with glaciers and only the very tops of the higher peaks were visible. The “rivers of ice” sculpted the mountains and valleys into a variety of landforms associated with major alpine and valley glacial action. Even though the Ice Age glaciers are gone, the results of their passing are evident on the landscape. Massive U-shaped valleys, numerous cirque lakes or tarns, horns, cols, moraines, and aretes are but a few of the glacially carved landforms that contribute to the beauty of Waterton-Glacier International Peace Park.

**Recent Glaciation – dating from about 6,000 years ago**

Today, we are living in a relatively warm interglacial period. All remnants of the Pleistocene ice have disappeared. There are no active glaciers in Waterton Lakes National Park; however, the last survey in Glacier NP resulted in 27 named alpine glaciers. They are of relatively recent origin, having formed in the last 6,000 to 8,000 years. They probably grew rapidly during the Little Ice Age that started about 400-500 years ago and ended about 1850. However, they work in the same way as larger glaciers of the past.

A glacier forms when more snow falls each winter than melts the next summer. With alternating freezing and thawing, the snow becomes granular ice. As these layers build up, the ice recrystallizes, becomes denser, and eventually forms a massive sheet. The ice needs to be about 100 feet (30 m) thick for a glacier to form and have a surface area of at least 25 acres. (10 ha). Ice near the surface of the glacier is often hard and brittle. Due to the pressure of ice above, the ice near the bottom of the glacier becomes flexible. This flexible layer allows the ice to move. Depending on the amount of ice, the angle of the mountainside, and the pull of gravity, the ice may start to move downhill. Once the ice begins to move, it is called a glacier. As the ice moves, it plucks rock from the sides and bottom of the valleys. Rocks falling on the glacier from above mix with the glacial ice as well. Over long periods of time the sandpaper-like quality of the moving ice and rock scours and reshapes the land into broad U-shaped valleys, sharp peaks, and lake-filled basins.

Tree-ring studies indicate that retreat of the recent glaciation began about 1850. When Glacier National Park was established in 1910, there were more than 150 glaciers within the national park compared to about one fourth of that number now. Retreat rates appear to have been slow until about 1910. There was a period of rapid retreat during the mid- to late 1920s. This corresponds to a period of warmer summer temperatures and decreased precipitation in this region. Several of the larger glaciers separated into two smaller glaciers at this time. The Jackson and Blackfoot Glaciers separated as did the Grinnell and Salamander Glaciers. If the current rate of recession continues, it is estimated that there won't be any glaciers in Glacier National Park by 2030.

**What sets our mountains apart?**

- There is a relatively flat lying Lewis Thrust sheet from which our mountains formed. The mountains of Waterton-Glacier are a result of one major fault and many minor ones, instead of many major and minor faults often found in mountain ranges, such as the front ranges of Banff and Jasper National Parks in Alberta. The fault extends from south of Marias Pass north 348 miles (560 km) to Banff NP, thrust in a northeasterly direction and coming to rest after millions of years. Most of the horizontal displacement occurred in the Waterton-Glacier area.
- The ancient rocks of the Belt Sea that form our mountains have much less limestone (limestone is mainly a by-product of sea life) and fewer fossils than the younger rock exposed in most of the Rockies.
- The Lewis Thrust sheet was displaced about 50 miles (80 km), as opposed to thrust sheets in the rest of the Rockies that were displaced over much shorter distances.
- The varied colors of the rock in the mountains, including the reds, greens and maroons are the result of small amounts of various iron minerals.
- There is an abrupt transition of mountains and prairie. Although the disturbed subsurface rock structures typical of foothills are present here, they are covered by glacial debris.
- Here is the oldest exposed sedimentary rock in the entire Rocky Mountain chain – 1.6 billion years old.

**The Continental Divide**

The Continental Divide separates the Atlantic and Pacific watersheds of North America. In Glacier, the divide follows the crest of the Lewis Range from Marias Pass to Flattop Mountain and then swings west to the crest of the Livingston Range, which it follows into Canada. The Continental Divide forms the western border of Waterton Lakes National Park, which lies completely on the east side of the divide. In Waterton, all drainages flow into the Saskatchewan River Basin, generally a northeast route towards Hudson Bay.

**Triple Divide**

In Glacier National Park, there is actually a triple divide because waters potentially can flow into three oceans. The creeks and streams in the southeast section of the park feed into the Birch and Marias Rivers, then the Missouri and the Mississippi and empty into the Gulf of Mexico. The water in the northeast section feeds into the St. Mary River that joins the Saskatchewan River Basin. From there, some of the water flows into Lake Winnipeg, then into the Nelson River which drains into the Hudson Bay. All water west of the divide feeds into the Flathead River, which then flows through Flathead Lake and empties into the Clark Fork which joins the Columbia River to the Pacific. The many streams of Waterton-Glacier make important contributions to the great rivers of the continent. There are few other areas of similar size that generate a volume of water equal to that flowing out of the parks. Glacier's Triple Divide Peak (8020 ft/2446 m) is a rather rare hydrologic feature. From the summit, water flows to the Atlantic Ocean, the Pacific Ocean, and Hudson Bay. The peak can be viewed from the Going-to-the-Sun Road in the Two Dog Flats area, on the east side of the park. Other triple divides (hydrological apexes) are found in Jasper National Park and in Siberia.

## CLIMATE CHANGE

**Climate and the Greenhouse Effect**

The earth's climate system is a complex and dynamic tapestry woven of physical processes and many individual components. These components may be gaseous (atmosphere), fluid (oceans, or solid (land, ice and snow, terrestrial, and marine life forms) and they may interact with each other on many different time scales (20,000 years for a sheet of ice to sculpt a mountain ranger or 1 week for a hurricane to cruise up the East Coast). One of the key components of earth's climate system is the Greenhouse Effect- the thermostat.

Life on earth exists because temperatures favored the creative process. Interestingly enough, these favorable temperatures have been perpetuated by... life on earth. The planet is warmed by sunlight and radiates the resultant heat in the form of infrared energy. If all of this radiated heat were to escape into space, the planet's temperature would be too cold to support life. Luckily, some of the radiated heat is trapped in the atmosphere by the gas carbon dioxide (and other gases: water vapor, methane, halocarbons, ozone, and nitrous oxide). This trapped heat warms the planet's surface, allowing life forms to thrive and grow- hence the name "greenhouse."

Life on Earth is described as carbon based - utilizing carbon as the central element in its molecular structure. Carbon is fixed or stored in living tissue during the growth process and it is released into the atmosphere during the process of decomposition. When the planet grows too cool, more living forms die, decompose, and release carbon dioxide into the atmosphere. This in turn increases infrared energy absorption which then raises the temperature of the planet and promotes the growth of life forms. So the temperature of the planet is continually fluctuating up and down within a favorable range and at a rate that is determined by the growth and decomposition cycles of the life forms. This very neat system for regulating Earth's temperature works relatively smoothly as long as the parameters of the equation remain the same. They haven't.

Rising concentrations of $CO_2$ and other green house gases are intensifying Earth's natural green house effect. The concentration of $CO_2$ has risen about 30% since the late 1800's. The concentration of $CO_2$

is now higher than it has been in at least the last 400,000 years. This increase has resulted from the burning of coal, oil, and natural gas, and the destruction of forests around the world to provide space for agriculture and other human activities. As we add more $CO_2$ and other heat-trapping gases to the atmosphere, the world is becoming warmer.

***The following information courtesy of Glacier's Crown of the Continent Research Learning Center.***

**Climate Change and Biotic Patterns**
A biologically diverse ecosystem, Glacier National Park is a highly heterogeneous landscape that is home to a rich diversity of plants and animals. One reason for this is the steepness of the terrain. With high mountains and low valleys, dense forests and open meadows, and numerous wetland habitats, Glacier can provide a home to an amazing array of species. But as climate changes, ecosystems will change too. Exactly how our current warming climate will affect Glacier's biotic communities is an active area of scientific research.

Climate helps determine what flora and fauna exist in a habitat. Every species has temperature and moisture ranges within which they can survive and thrive. Glacier's weather and climate can be highly variable from high to low elevations and also between the east and west sides of the Continental Divide. The cool, harsh high alpine environments support very different species than the milder conditions usually found at lower elevations. East of the divide tends to be colder and drier than west because the Pacific maritime climate delivers moisture and heat from west to east. The temperature range, amount of rain, wind, and other climatic conditions that each part of the park receives helps to define the kinds of organisms found there. While not static, these micro-climates create diversified and distinct communities within the landscape.

As climate changes, plants and animals adapted to current conditions and locations will either need to adapt to survive in different conditions or "follow" the temperature range in which they can survive. The ability of populations to adapt or move when climate changes depends on many factors, one which is the rate of change. The current warming climate is accelerated by human activities and it is unclear how, or even if, most modern species can adapt well enough to survive. In a warming climate, vegetation zones will tend to migrate northward and/or up-slope to higher elevations. Alpine treeline studies help scientists understand how this process takes place. Studies from Glacier suggest forest patches at high elevations are getting denser and are beginning to invade alpine meadows. Of major concern is the potential loss of alpine and subalpine environments that provide prime habitat for plants such as Jones Columbine and White Mountain Avens, animals like bighorn sheep and mountain goats, and winter hibernation space for bears. Species living here cannot migrate to higher ground.

While some species may be able to move and adapt to climate change, the current rapid rate of warming may present significant difficulties for others. Some vegetative communities, such as old growth forests, are not capable of migrating quickly. In other cases, migration may not occur due to lack of suitable corridors that connect current locations to higher or more northern territories where the plants can become established and thrive. Roads, urban and industrial areas, and agricultural fields all present obstacles to the migration potential of plants and animals. Species that cannot adapt or move, will not survive.

**Changes In Disturbance Regimes**
Climate change will effect not only the types of plants and animals that can survive in certain areas, it will also impact processes that shape the landscape such as fire. For example, changes to temperature and precipitation patterns will effect soil moisture as well as the frequency of storms (which bring

lightening that start fires). In general, under warming conditions, scientists expect there to be a greater potential for more frequent, larger, more severe, and more intense wildland fires. While fire is an important shaper of Glacier's landscape, too intense or too frequent fires may make it more difficult for native species to return. Disturbance by fire may create an ideal environment for non-native, invasive species to thrive.

### Global Climate Change and Melting Glaciers

Global warming is one of the most pressing environmental issues of the 21st century. For many years, scientists have been studying this phenomenon and the evidence is now clear. Earth's climate is warming and mountain ecosystems like those found in Glacier National Park are seeing some of the most dramatic changes. In the last 100 years, global average temperature increased by 1.6 degrees Fahrenheit with accelerated warming over the last two to three decades. The 1990s were the hottest decade, not just of the last century, but of the last millennium! The 5 hottest years of record since the 1890s, in rank order, were 2005, 1998, 2002, 2003, and 2004. Scientists predict that by the end of the 21st century Earth will experience a warming trend of 2-10 degrees. While this may not seem like much, it could bring major changes to Earth's ecosystems, especially those at high altitudes and latitudes like Glacier National Park.

While Earth's climate is known to have changed in the past due to natural causes, the warming trend over the last few decades is primarily the result of human activities. Of major concern is the buildup of carbon dioxide and other "greenhouse gases" in the atmosphere. Greenhouse gases hold heat in the atmosphere that would otherwise radiate back out into space. While the greenhouse effect is what has made life on Earth possible, these gases are now increasing at an alarming rate. Since the beginning of the industrial revolution, the carbon dioxide concentration in the atmosphere has increased by 30%. Human activities that release carbon dioxide are burning of fossil fuels, harvesting and burning trees, and land conversion to cities and agriculture.

### Melting Mountain Glaciers

Glaciers are formed when more snow falls in winter than melts in summer. As snow accumulates over many seasons it becomes ice. The weight from snow and ice causes the bottom layers to move, fashioning a frozen river of snow and ice that slowly flows across the landscape, eroding and shaping it into unique landforms. When this process is reversed, the glaciers retreat back up the mountain. The advance and retreat of glaciers is strongly tied to temperature and precipitation and is a simple, but affective way to monitor climate change. The amazing mountains and valleys of Glacier National Park were sculpted by the action of glaciers over hundreds of thousands of years of glacial advance and retreat. In 1850, at the end of the Little Ice Age, there were an estimated 150 glaciers in the park. By 1968, these had been reduced to around 50, 37 of which had been named. Today the number of glaciers in the park is 27, many of which are mere remnants of what they once were.

Rapid retreat of mountain glaciers is not just happening in Glacier National Park, but is occurring worldwide. While Earth's climate has undergone cooling and warming cycles in the past, the rate and magnitude of change we are witnessing today has not occurred since human civilization began. If the current rate of warming persists, scientists predict the glaciers in Glacier National Park will be completely gone by the year 2030. The total loss of glaciers will certainly be a major change for Glacier National Park. For many people, the glaciers are one of the reasons the park holds special significance and are a feature they expect to see when they visit. Glaciers are also an important natural resource, providing vital functions for the ecosystem.

### Climate Change and the Water Cycle: Water Towers of the World

Glacier National Park is famous for its mountainous landscape and glacially carved terrain. What many people don't realize is that mountain glaciers provide more than just scenery. Glaciers are an integral part of the ecosystem, providing water to mountain and downstream environments. In today's warming climate, these giant marvels of snow and ice are rapidly disappearing.

Mountains have been called "water towers of the world." More than 50% of the world's fresh water supply comes from runoff in mountain environments. While much of the runoff from mountains comes from rain and melting snow, alpine glaciers are an important contributor to mountain stream flow. Globally, glacial meltwater provides one-fourth of the water in mountain streams. By providing a dependable source of cool, fresh water, glaciers are essential to the health of aquatic and riparian ecosystems. They also provide fresh drinking water for downstream populations and dilute pollutants that are generated mostly in lowland areas. As climate warms and glaciers melt, these ecosystems are losing an important source of fresh water.

Glacier National Park has already lost more than 70% of its glaciers in the last century. Today there are 27 of the 150 glaciers that were recorded in 1850, the end of the period called the Little Ice Age. At the present rate of warming, scientists predict that all of the glaciers in Glacier Park will be gone by the year 2030. The demise of glaciers will affect both the amount and timing of mountain stream flow.


**Stream Regulators**

Mountain streams in Glacier National Park are fed by alpine glaciers and snowpack. In summer, once it becomes warm enough to melt the snowpack, a rush of water comes down the mountains from glaciers to join the streams and rivers. Then, for the rest of the warm season, mountain streams are augmented by a constant flow from melting glaciers. When rain is sparse, as in the late summer and during drought years, mountain glaciers may be the only source of base flow in some mountain streams.

As climate warms, this pattern is changing. With a warming climate, less winter precipitation falls as snow but more of it falls as rain. Also, spring comes earlier. The longer warm season will allow even more snow and ice to melt. Earlier, warmer summers mean spring runoff from mountains happens earlier in the year, and often in a bigger rush of water downstream. In the Pacific Northwest region, spring runoff is now happening up to two weeks earlier than it used to. A concern with global warming is the possibility of more spring floods due to the pulses of rain combined with melting snow and ice.

As mountain glaciers melt and spring runoff happens earlier, there is less water later in the season. For many small mountain streams, melting glaciers provide the only source of base flow in late summer. With no glacial meltwater to augment them, some streams may become ephemeral, drying up late in the season. This will have major consequences for stream ecology. In addition to regulating stream flow, glacial meltwater effects the temperature of mountain streams and rivers. Many of the invertebrates that live in Glacier National Park's waters are very temperature sensitive and can only live within a narrow temperature range. Because aquatic invertebrates are at the base of the food chain, putting them at risk threatens the entire stream ecosystem.

**Glacier's Management Strategy**

Climate change, especially the rapid change we are currently experiencing, is a serious issue. As scientists work to understand how Glacier's ecosystems will be impacted, managers struggle to understand what kinds of decisions can and should be made in the face of these changes to protect park resources. It is unlikely that any management actions would be sufficient to preserve Glacier National Park in its current state. Some level of change is inevitable and may even be desirable. Unfortunately, there is no simple solution. In some cases, managers may be forced to choose when and where to invest limited time and energy for resource protection and restoration. For example, areas such as old growth cedar-hemlock forests, that evolved in a much colder climate, may simply have to be understood as remnants of another time. In other cases, park managers may need to work with other agencies and land managers to identify and protect corridors that connect important wildlife habitats to allow species to migrate. Management strategies for disturbances such as fire and invasive plants will need to adapt to the context of climate change pressures. Research and internal education efforts can help park staff become aware of the issues and can encourage discussions that may provide new ideas and approaches. Engaging the support of our neighbors and partners will be critical as we seek solutions to these complex issues.

Changes to the status of aquatic systems due to climate change is of great concern to Glacier Park managers. Park staff work closely with research scientists to monitor stream health. Healthy streams have been identified as a park "vital sign," which means they are an important indicator of the overall integrity of Glacier's ecosystems. Vital Signs monitoring is part a national program in the National Park Service to understand the state of natural resources and provide an early warning for park managers of changes in ecosystem health. Many natural resources in the National Park System are subjected to unfavorable impacts from a variety of sources, including climate change. Left unchecked, the very existence of many natural communities can be threatened. To help prevent the loss or impairment of such communities in approximately 270 parks nationwide, the NPS Inventory and Monitoring (I&M) Program was established as part of the Natural Resource Challenge in 1999.

The principal functions of the I&M Program are the gathering of information about the resources and the development of techniques for monitoring the ecological communities in the National Park System. Ultimately, the inventory and monitoring of natural resources are integrated with park planning, operation and maintenance, visitor protection, and interpretation to sustain the preservation and protection of these resources. The I&M Program is designed to help parks preserve healthy parks by acquiring timely and accurate information about the condition of natural resources and monitoring any changes over time so that managers can act on that information with confidence. Park employees monitor the health of aquatic environments. Many aquatic organisms are highly temperature sensitive. Warmer water and reduced stream flow later in the year could have very detrimental consequences for these systems.

Now that the impacts of global warming are beginning to be understood, managers are taking the issue very seriously. Ultimately, greenhouse gas emissions, especially carbon dioxide, must be reduced. The National Park Service, in partnership with the Environmental Protection Agency, held a workshop in Whitefish, MT for park personnel in December 2003 to discuss the issues relating to climate change in the park and what steps the park can take to respond to this threat. An assessment of greenhouse gas emissions from Glacier was conducted prior to the  workshop to provide background what the primary activities are that can be targeted for emissions reduction. The single greatest contributor to carbon dioxide emissions in the park is transportation. Other significant sources are energy use in buildings and solid waste disposal. A number of the actions from the plan have already been taken to reduce greenhouse gas emissions and raise awareness of the issues. These include employee transportation alternatives like the Red Bike Program and bus and carpooling initiatives, as well as a recycling plan, and monitoring energy use in buildings. Visitor transportation options are also being planned in conjunction with the Going-to-the-Sun Road rehabilitation project.

Ice Patch Archeology Study, www.glacieriepatch.org
Unlike glaciers, ice patches do not move at all, so encased objects remain in the same spot. Researchers studying ice patches identify and document artifacts and organic materials left behind as the ice melts. Such finds can include animal bones and scat, leaves deposited by wind, fragments of ancient wood, and lost Native American artifacts. From 2009-2013, a collaborative research team investigated 46 of Glacier National Park's ice patches. The Glacier National Park Ice Patch Project's purpose was to document ice patch melting, collect remains of ancient plants and animals, and to protect Native American cultural artifacts associated with hunting and travel in Glacier's high-elevation regions.

Glacier National Park has always been iconic for its beautiful mountain landscapes, and is now unfortunately the 'poster child' for climate change-related losses of glaciers, ice patches, and the values associated with alpine and sub-alpine landscapes, ecosystems, and heritage values. The Glacier Ice Patch Archeology and Paleoecology project has yielded scientific and cultural information about past climates and cultures that can inform resource stewards as well as capture the public imagination.